IBM Technical Papers Published in Other Journals

Automatic Preparation of Flow Chart Listings, A. E. Scott, *Journal of the Association for Computing Machinery,* **5,** No. 1, 57-66 (January, 1958).

This paper describes a means of automatically producing a flow-chart listing, which is the actual listing of a computer program blocked out to show logical flow. The paper discusses how this is accomplished, including the following: collecting information about transfers and program switches; determining how much is to go on each page; arranging the transfers in tables according to specific conditions; assigning identifications to some transfers; framing the blocks; and positioning the arrows. It indicates what information must be supplied by the programmer and describes the capacity of the program. An example of a typical operation is given, and some of the possible extensions of the method are explored.

Band Structure of Graphite, J. C. Slonczewski and P. R. Weiss, *Physical Review,* **109,** No. 2, 272-279 (January 15, 1958).

Tight-binding calculations, using a two-dimensional model of the graphite lattice, lead to a point of contact of valence and conduction bands at the corner of the reduced Brillouin zone. A perturbation calculation which starts with wave functions of the two-dimensional lattice and is applied to the three-dimensional lattice is described. Some general features of the structure of the π bands in the neighborhood of the zone edge are obtained and are expressed in terms of appropriate parameters.

Bootstrapped Differential Amplifier with Reduced Common-Mode Effects, R. J. Blume, *Review of Scientific Instruments,* **29,** No. 2, 122-124 (February, 1958).

The appearance of a common-mode voltage at both grids of a conventional twin-triode differential amplifier produces, by cathode-follower action, an equal swing of the common cathode point. The resulting change in the operating point of the tubes causes undesired shifts of both the differential gain and the balance of the amplifier. In the present work, the change of voltage at the common cathode point is entirely transferred ("bootstrapped") to the plate supply, with the result that a common-mode voltage does not affect the operating points of the differential-amplifier tubes. By this means, a common-mode rejection ratio of $> 10^4$:1 is readily achieved without tube selection or adjustments. With tube selection and some adjustment, $> 10^5$:1 may be obtained. A common-mode signal of ± 35 v changes the differential gain of the circuit by 0.5% or less. A bootstrapped differential VTVM circuit which deflects a 1 ma, 1.5 *K*-ohm pen recorder to full scale with ~0.2 v dc input is described in detail.

Dimensional Stability Problems in Converting and Processing Punched Cards, J. L. Morton, *Tappi,* **41,** No. 3, 124-128 (March, 1958).

A number of expansivity problems associated with punched card paper stock are presented, along with control procedures used in the manufacturing process. Effects of humidity are described, and a description of punched card operations (card punching, feeding, reading, and stacking) points out the importance of quality control of dimensional stability and of moisture content.

Effect of Cation Vacancies on the Magnetic Annealing of Cobalt-Substituted Magnetite, L. R. Bickford, Jr., J. M. Brownlow, and R. F. Penoyer, *Journal of Applied Physics,* **29,** No. 3, 441-442 (March, 1958).

Five crystals of nominal composition $Co_{0.1}Fe_{2.9}O_4$, grown from the melt under different partial pressures of oxygen, were subjected to magnetic annealing at 100°C. The relaxation time characterizing the annealing process is shown to increase from several minutes, for crystals known to contain cation vacancies, to a value too large to be determined, for a crystal essentially stoichiometric with respect to oxygen content. The observed changes in relaxation time and magnitude of the anneal-induced anisotropy are interpreted as the effect of cation vacancies on the ease of movement of cobalt ions between equivalent cation sites during the annealing process.

Electron Spin Relaxation Times in Sodium-Ammonia Solutions, R. J. Blume, *Physical Review,* **109,** 1867-1873 (March 15, 1958).

The transverse and longitudinal relaxation times (T_2 and T_1) were measured at 17.4 mc (6.2 gauss) by rf pulse techniques. The value T_2 was obtained by measuring the decay time of the free-induction signal following a 90° flip, and was found to vary from about 3.2 μsec to 0.7 μsec as the sample concentration varied from 1.1 to 25.9 mg Na/g NH_3. The value T_1 was measured by the 180°-90° method over a concentration range of 4.9 to 16.9 mg Na/g NH_3. It was found that T_1 equals T_2 in this range to within about $\pm 10\%$, in accord with the theory of Bloembergen, Purcell, and Pound. Spin echoes from electrons were observed. Descriptions of the apparatus and the method of preparing the samples are included.

Ferrimagnetic Resonance in Gadolinium Iron Garnet, B. A. Calhoun, W. V. Smith, and J. Overmeyer, *Journal of Applied Physics,* **29,** No. 3, 427-428 (March, 1958).

Ferrimagnetic resonance in single crystals of gadolinium iron garnet has been observed at 9479 and 23,725 mc. Crystals from two different preparations have different compensation points (13° and 32°C). The resonance behavior is discussed in terms of a two-sublattice theory. The value g_{Gd} is equal to 2.006 above −90°C and increases at lower temperatures. The gadolinium ions contribute to the anisotropy below −40°. An extra resonance observed near the compensation point is attributed to inclusions in the crystals. The gadolinium apparently contributes substantially to the total damping of the magnetization.

Human Factors Engineering — A Working Program, A. H. Schroeder, *Mechanical Engineering,* **80,** No. 4, 52-53 (April, 1958).

The recent increase of human factors engineering problems, resulting from the rapid advancement of technology, has produced a challenge to industry. To approach these problems successfully requires a well-coordinated effort between the engineer and the engineering psychologist, plus the support of top management. Many industrial managements are recognizing this and are establishing human factors engineering groups in both research and development areas. This paper shows how one major industrial concern is meeting this challenge. It discusses why a human factors engineering program is necessary, what some of the typical engineering problems are, how they are being solved, and the advantages of such a program. In addition, the paper includes general information about professional societies recently formed and the progress of educational programs in this field.

Ionic Valences in Manganese-Iron Spinels, A. H. Eschenfelder, *Journal of Applied Physics,* **29,** No. 3, 378-380 (March, 1958).

Magnetic-moment data for specimens of spinels in the composition range Mn_3O_4 to Fe_3O_4 are reported and an interpretation of the data in terms of the distribution of ions of manganese and iron is presented.

The data agree with previous indications that manganese ferrite, $MnFe_2O_4$, is an almost completely normal spinel with Mn^{2+} on *A* sites and Fe^{3+} on *B* sites. In addition, the usual assumption that excess iron replaces manganese as Fe^{2+} on *B* sites is substantiated. However, the data are not compatible with the previously held assumption that Fe^{3+} is replaced by excess manganese as Mn^{3+}. Instead, the variation of magnetic moments and Curie temperatures with composition is interpreted in terms of a model in which excess manganese replaces Fe^{3+} as Mn^{4+} and an equal amount of iron is converted to Fe^{2+}. When the manganese content gets so high that all the iron is Fe^{2+} (Mn_2FeO_4), manganese then replaces the iron as Mn^{3+} and reconverts an equal amount of Mn^{4+} to Mn^{3+}, and the Mn^{3+}, because of its tetragonal nature, introduces spinel twinning.

It is proposed that the $Mn^{4+}-Fe^{2+}$ pair in octahedral coordination is stabilized with respect to a $Mn^{3+}-Fe^{3+}$ pair because of the interaction of the manganese orbitals with the 2*p* orbitals of the surrounding oxygen anions.

Large Digital Computer Dependability Measurement, G. B. McCarter and J. Gold, *Proceedings of the Fourth National Symposium on Reliability and Quality Control in Electronics,* pp. 95-112 (January, 1958).

Dependability engineering (commonly termed "reliability engineering") has been developed mainly in relation to aircraft and guided-missile equipment. The methods used in measuring the dependability of such equipment are not entirely adequate for measuring the dependability of a general-purpose, large-scale, digital computer.

It is the purpose of this paper to discuss:

1. The problems encountered when attempting to derive measurements which would adequately describe the dependability of such a computer (the AN/FSQ-7).
2. The functions defined for measuring the dependability of this computer (reliability, maintainability, availability and computing efficiency).
3. The problems encountered when attempting to measure from field data the parameters associated with these functions.

Dependability data from early operational phases of the AN/FSQ-7 and its prototype, XD-1, will be presented for illustrative purposes. The AN/FSQ-7, which is used in the SAGE System, has 50,000 vacuum tubes and over 1,000,000 components. The XD-1 has 20,000 tubes and 400,000 components.

Magnetic Moment of the Free Muon, T. Coffin,* R. L. Garwin, S. Penman,* L. M. Lederman,* and A. M. Sachs,* *Phys. Rev.,* **109,** 973-979 (February 1, 1958).

The magnetic moment of the positive μ-meson has been measured in several target materials by a magnetic resonance technique. Muons were brought to rest with their spins parallel to a magnetic field. A radio-frequency pulse was applied to effect a spin reorientation which was detected by counting the decay electrons emerging after the pulse in a fixed direction. Results are expressed in terms of a *g* factor which for a spin ½ particle is the ratio of the actual moment to $eh/2m\mu c$. The most accurate result obtained in a $CHBr_3$ target, is that $g=2(1.0026\pm0.009)$ compared to the theoretical prediction of $g=2(1.0012)$. Less accurate measurements yielded $g=2.005\pm0.005$ in a copper target and $g=2.00\pm0.01$ in a lead target.

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A Method of Tooling Cavities for Quality Class Commercial 2 Spur and Helical Plastic Molded Gears, J. R. Venne, *Technical Papers of the 14th Annual National Technical Conference, Society of Plastic Engineers,* **IV,** 686-696 (January, 1958).

A generally satisfactory method of making mold-cavity patterns for plastic gears smaller than 1½ inches in diameter is to cut the teeth of the gear-cavity pattern oversize by the amount of anticipated shrinkage, using standard tools on a gear-hobbing machine. This method, however, is not satisfactory for larger gears because shrinkage becomes so great in the gear body that tooth action, as a result of tooth-to-tooth variation and composite radial variation, is impaired beyond tolerance limits. The problem is to modify the mold-cavity dimensions to compensate for shrinkage in large gears.

This paper describes a method developed by the IBM Endicott Plastics Laboratory to make the gear-cavity pattern used to produce the mold for "Quality Class Commercial 2" plastic molded gears. The method has been used successfully to mold gears from 1½ up to 4½ inches in diameter.

Methods of Affecting the Dimensional Stability of Paper, H. O. George, *Tappi,* **41,** No. 1, 31-33 (January, 1958).

This paper presents a number of variable factors which can affect the dimensional stability of paper—the physical and chemical properties of the pulp, the degree of refining, the fiber orientation, and tension during drying—all closely related to hygroexpansivity. The influences of beater additives and surface sizing are described, along with the effects of calendering and the use of mineral fillers and inert synthetic fibers on expansivity. Chemical treatments which impart dimensional stability are listed, as well as the effects of paper coatings, impregnations, and laminations with inert films such as metal foil or plastics.

Model for Nonlinear Flux Reversal of Square-Loop Polycrystalline Magnetic Cores, M. K. Haynes, *Journal of Applied Physics,* **29,** No. 3, 472-474 (March, 1958).

The theory of the reversal wave forms of polycrystalline magnetic cores proposed by Goodenough is based on the growth of ellipsodial domains of reverse magnetization which originate from nucleating centers at grain boundaries. The present model extends this theory with the assumption that the nucleating centers are randomly distributed throughout the core volume. Radial field variations are neglected.

The rate of change of reversed magnetization area of the irreversibly moving and colliding walls is calculated as a function of their position, starting from a Poisson distribution of nucleating centers, and then converted to a function of flux. The equation derived for rate of flux change is

$$\frac{dx}{dt} = \frac{4.82}{S_w}(H-H_0)(1-x)\left(-ln\frac{1-x}{2}\right)^{2/3},$$

where S_w is the switching coefficient, H_0 is the threshold field, H is the applied field, and x is the ratio of flux density to retentivity.

This nonlinear differential equation is solved for the simple case of constant-current drive. For more complicated circuit conditions, solution of the core equation require numerical methods. Programs have been written for the IBM 704 Data Processing Machine to calculate the behavior of circuits containing many such cores interacting and switching together. Results obtained check reasonably well with experimental evidence.

Numerical Calculations of the Wave Functions and Energies of the 1^1S and 2^3S States of Helium, D. H. Tycko, L. H. Thomas, and K. M. King, *Phys. Rev.,* **109,** 369-374 (January 15, 1958).

An exact iteration method for obtaining solutions to the eigenvalues problems of quantum mechanics is used as the basis for developing a numerical iteration scheme for the approximate solution of such problems. The connection between an approximate analytic iteration method and the standard variational method is made and the former method is applied to the 1^1S state of He. The wave functions so determined are linear combinations of products of hydrogen-like wave functions. The best value of the energy obtained with twenty parameters is $E(1^1S) = -2.900938$ au. By using the theory of Gaussian quadrature and least-squares approximation, a systematic transition from an exact iteration method to the numerical iteration method can be made. The resulting numerical scheme is applied to the 1^1S and 2^3S states of He. The energies obtained are $E(1^1S) = -2.903443$ au. and $E(2^3S) = -2.174823$ au. The 2^3S wave function yields a He^3 hyperfine splitting $\nu = 6664$ mc, which is lower than the experimental value by about 1%. The wave functions obtained are expressible in both the coordinate and momentum representations.

Origin of Magnetic Anisotropy in $Co_xFe_{3-x}O_4$, J. C. Slonczewski, *Journal of Applied Physics,* **29,** No. 3, 448-449 (March, 1958).

A model is proposed to explain the large part of the ferromagnetic anisotropy energy of $Co_xFe_{3-x}O_4$ (where x is small) which is caused by the presence of Co^{2+}. The residual orbital angular momentum $\alpha(\sim 1)$ of CO^{2+} is constrained by the crystal field to lie parallel to the axis of threefold symmetry. Spin-orbit energy $\lambda L \cdot S$ couples the spin to this axis, accounting for the anisotropy energy. By fitting the theory to experimental anisotropy data, one finds that $|\alpha\lambda| = 132$ cm^{-1}. The assumption that cations are mobile at higher temperatures leads to an explanation of the anisotropy induced by magnetic annealing.

Preferential Volatilization of Cations from Ferrites During Sintering, J. M. Brownlow, *Journal of Applied Physics,* **29,** No. 3, 373-375 (March, 1958).

The abnormal plots of reduced magnetization vs temperature for ferrites containing zinc are found to be associated with a concentration gradient in zinc that is generated by the preferential loss of zinc during sintering. The variation of the gradient in samples of zinc-iron spinels is correlated with sintering and annealing treatment and with sample dimensions.

Reactions of the Group VB Pentoxides with Alkali Oxides and Carbonates. VII. Heterogeneous Equilibria in the System Na_2O or Na_2CO_3—Nb_2O_5, A. Reisman, F. Holtzberg and E. Banks,* *Journal of American Chemical Society,* **80,** 37-42 (1958).

The heterogeneous equilibria in the system Na_2O or Na_2CO_3 with Nb_2O_5 have been investigated using differential thermal analysis, X-ray analysis and density measurements. Four compounds corresponding to the formulas (I) $Na_2O \cdot 14Nb_2O_5$, (II) $Na_2O \cdot 4Nb_2O_5$, (III) $Na_2O \cdot Nb_2O_5$ and (IV) $3Na_2O \cdot Nb_2O_5$, have been identified. Compounds I and II melt incongruently at 1309 and 1277°, respectively, and compounds III and IV melt congruently at 1422 and 997°, respectively. The polymorphism of compound III has been reinvestigated, and results indicate the existence of four phases with transitions at 640, 562 and 354°. The 562° transition was ob-

servable, as a sharp heat effect at this temperature, only after extensive annealing. In a re-examination of the polymorphic behavior of Na_2CO_3, latent heat anomalies were observed at 485 and 355°. X-ray powder data have been obtained for compounds I, II, III, and IV.

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Small-Business Management and Systems Problems, Z. M. Radner, *Ideas for Management* (Proceedings of the 10th International Systems Meeting, Systems and Procedures Association of America) pp. 442-448 (1958).

This paper is a detail report by the Chairman of the Industry Seminar covering some problem areas and characteristics of small business.

Solar Sailing—A Practical Method of Propulsion Within the Solar System, R. L. Garwin, *Jet Propulsion,* **28,** 188-189 (March, 1958).

It is shown that commercially available metallized plastic film can be used as a solar radiation pressure sail for propulsion of space vehicles within the solar system. The method of propulsion is of negligible cost and is perhaps more powerful than many competing schemes.

Standardization by Machine Methods, A. H. King, *Proceedings of the Sixth Annual National Meeting of the Standards Engineers Society,* pp. 48-62 (September, 1957).

This paper describes the use of data processing machines to handle and solve many of the problems in a parts-standardization program. Parts of all kinds are cataloged according to their dimensions and/or characteristics to provide a ready reference to the parts for new applications. Time is saved and duplication avoided. Analysis of the new applications provides guidance in the development of new or improved standards. Continuing analysis determines the effectiveness of the standards. Guesswork and opinion are eliminated and standards guidance and evaluation are based on up-to-date facts.

Techniques for Measuring and Evaluating Noise, J. J. Hamrick, *Journal of The Audio Engineering Society,* **6,** No. 1, 19-25 (January, 1958.)

An increasing awareness of and concern for noise levels in industrial environments has required the development of improved techniques and procedures to measure and evaluate the noise levels of new products. This paper describes a number of improved operational procedures for, as well as a number of modifications to, stereo tape recorders and reproducing systems, audio-spectrum analyzers, graphic level recorders, and frequency analyzers. Noise levels generated in data-processing rooms are correlated with laboratory measurements in anechoic and reverberant chambers. Annoyance evaluations are included, as well as the technique of carefully selecting a well-qualified listening panel.

Use of Thermal Expansion Measurements to Detect Lattice Vacancies Near the Melting Point of Pure Lead and Aluminum, R. Feder,* and A. S. Nowick, *Physical Review,* **109,** 1959-1963 (March 15, 1958).

Dilatometric and X-ray measurements of the thermal expansion of pure lead and aluminum have been carried out between room temperature and the melting point. For lead, the results obtained by the two techniques agree within experimental error, which is interpreted to imply that the vacancy concentration at the melting point is (in mole fraction) less than or equal to 1.5×10^{-4}. For aluminum the dilatometric expansion appears to be slightly greater than the X-ray expansion. If this discrepancy is real, it corresponds to a vacancy concentration at the melting point of aluminum of about 3×10^{-4}. The corresponding estimate for the formation energy, ε_v, of a vacancy in lead is $\varepsilon_v \geqq 0.53$ ev, and in aluminum $\varepsilon_v = 0.77$ ev.

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